003335E 2018–08

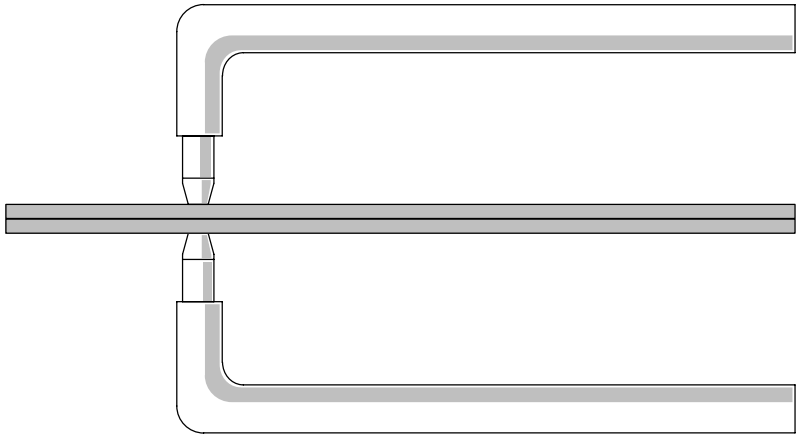
Processes

Resistance Spot Welding

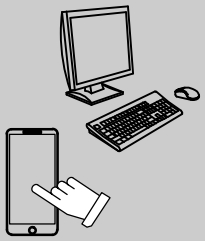
Description

1 Phase

Resistance Spot Welder



Guidelines For Resistance Spot Welding



For product information, Owner's Manual translations, and more, visit

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SECTION 1 – SAFETY PRECAUTIONS - READ BEFORE USING

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Protect yourself and others from injury — read, follow, and save these important safety precautions and operating instructions.

1-1. Symbol Usage

DANGER! – Indicates a hazardous situation which, if not avoided, will result in death or serious injury. The possible hazards are shown in the adjoining symbols or explained in the text.

Indicates a hazardous situation which, if not avoided, could result in death or serious injury. The possible hazards are shown in the adjoining symbols or explained in the text.

NOTICE *– Indicates statements not related to personal injury.*

☞ *Indicates special instructions.*

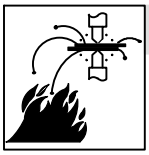
This group of symbols means Warning! Watch Out! ELECTRIC SHOCK, MOVING PARTS, and HOT PARTS hazards. Consult symbols and related instructions below for necessary actions to avoid the hazards.

1-2. Resistance Spot Welding Hazards

The symbols shown below are used throughout this manual to call attention to and identify possible hazards. When you see the symbol, watch out, and follow the related instructions to avoid the hazard. The safety information given below is only a summary of the more complete safety information found in the Safety Standards listed in Section 1-5. Read and follow all Safety Standards.

Only qualified persons should install, operate, maintain, and repair this equipment. A qualified person is defined as one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated ability to solve or resolve problems relating to the subject matter, the work, or the project and has received safety training to recognize and avoid the hazards involved.

During operation, keep everybody, especially children, away.



SPOT WELDING can cause fire or explosion.

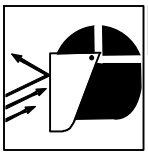
Sparks can fly off from the welding arc. The flying sparks, hot workpiece, and hot equipment can cause fires and burns. Accidental contact of electrode to metal objects can cause sparks, explosion, overheating, or fire. Check and be sure the area is safe before doing any welding.

- Remove all flammables within 35 ft (10.7 m) of the weld. If this is not possible, tightly cover them with approved covers.
- Do not spot weld where flying sparks can strike flammable material.
- Protect yourself and others from flying sparks and hot metal.
- Be alert that welding sparks can easily go through small cracks and openings to adjacent areas.
- Watch for fire, and keep a fire extinguisher nearby.
- Do not weld on containers that have held combustibles, or on closed containers such as tanks, drums, or pipes unless they are properly prepared according to AWS F4.1 and AWS A6.0 (see Safety Standards).
- Do not weld where the atmosphere can contain flammable dust, gas, or liquid vapors (such as gasoline).
- Remove any combustibles, such as a butane lighter or matches, from your person before doing any welding.
- After completion of work, inspect area to ensure it is free of sparks, glowing embers, and flames.
- Do not exceed the equipment rated capacity.
- Use only correct fuses or circuit breakers. Do not oversize or bypass them.
- Follow requirements in OSHA 1910.252 (a) (2) (iv) and NFPA 51B for hot work and have a fire watcher and extinguisher nearby.
- Wear body protection made from durable, flame–resistant material (leather, heavy cotton, wool). Body protection includes oil-free clothing such as leather gloves, heavy shirt, cuffless trousers, high shoes, and a cap.

ELECTRIC SHOCK can kill.

Touching live electrical parts can cause fatal shocks or severe burns. The input power circuit and machine internal circuits are also live when power is on. Incorrectly installed or improperly grounded equipment is a hazard.

- Do not touch live electrical parts.
- Wear dry, hole-free insulating gloves and body protection.
- Additional safety precautions are required when any of the following electrically hazardous conditions are present: in damp locations or while wearing wet clothing; on metal structures such as floors, gratings, or scaffolds; when in cramped positions such as sitting, kneeling, or lying; or when there is a high risk of unavoidable or accidental contact with the workpiece or ground. For these conditions, see ANSI Z49.1 listed in Safety Standards. And, do not work alone!
- Disconnect input power before installing or servicing this equipment. Lockout/tagout input power according to OSHA 29 CFR 1910.147 (see Safety Standards).
- Properly install, ground, and operate this equipment according to this manual and national, state, and local codes.
- Always verify the supply ground – check and be sure that input power cord ground wire is properly connected to ground terminal in disconnect box or that cord plug is connected to a properly grounded receptacle outlet.
- When making input connections, attach the grounding conductor first – double-check connections.
- Keep cords dry, free of oil and grease, and protected from hot metal and sparks.
- Frequently inspect input power cord and ground conductor for damage or bare wiring – replace immediately if damaged – bare wiring can kill.
- Turn off all equipment when not in use.
- For water-cooled equipment, check and repair or replace any leaking hoses or fittings. Do not use any electrical equipment if you are wet or in a wet area.
- Use only well-maintained equipment. Repair or replace damaged parts at once.
- Wear a safety harness if working above floor level.
- Keep all panels, covers, and guards securely in place.



FLYING SPARKS can injure.

Very often sparks fly off from the joint area.

- Wear approved face shield or safety goggles with side shields.

- Wear body protection made from durable, flame−resistant material (leather, heavy cotton, wool). Body protection includes oil-free clothing such as leather gloves, heavy shirt, cuffless trousers, high shoes, and a cap.
- Protect others in nearby areas by using approved flame-resistant or noncombustible fire curtains or shields. Have all nearby persons wear safety glasses with side shields.

HOT PARTS can burn.

- Do not touch hot parts bare handed.
- Allow cooling period before working on equipment.

- To handle hot parts, use proper tools and/or wear heavy, insulated welding gloves and clothing to prevent burns.

MOVING PARTS can injure.

The tong tips, tongs, and linkages move during operation.

- Keep away from moving parts.

- Keep away from pinch points.
- Do not put hands between tips.
- Keep all guards and panels securely in place.
- OSHA and/or local codes can require additional guarding to suit the application.

FUMES AND GASES can be hazardous.

Welding produces fumes and gases. Breathing these fumes and gases can be hazardous to your health.

- Keep your head out of the fumes. Do not breathe the fumes.
- Ventilate the work area and/or use local forced ventilation at the arc to remove welding fumes and gases. The recommended way to determine adequate ventilation is to sample for the composition and quantity of fumes and gases to which personnel are exposed.
- If ventilation is poor, wear an approved air-supplied respirator.
- Read and understand the Safety Data Sheets (SDSs) and the manufacturer's instructions for adhesives, coatings, cleaners, consumables, coolants, degreasers, fluxes, and metals.
- Work in a confined space only if it is well ventilated, or while wearing an air-supplied respirator. Always have a trained watchperson nearby. Welding fumes and gases can displace air and lower the oxygen level causing injury or death. Be sure the breathing air is safe.
- Do not weld in locations near degreasing, cleaning, or spraying operations. The heat and rays of the arc can react with vapors to form highly toxic and irritating gases.
- Do not weld on coated metals, such as galvanized, lead, or cadmium plated steel, unless the coating is removed from the weld area, the area is well ventilated, and while wearing an air-supplied respirator. The coatings and any metals containing these elements can give off toxic fumes if welded.

1-3. Additional Symbols For Installation, Operation, And Maintenance

FIRE OR EXPLOSION hazard.

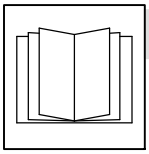
- Do not install or place unit on, over, or near combustible surfaces.
- Do not install or operate unit near flammables.

- Do not overload building wiring – be sure power supply system is properly sized, rated, and protected to handle this unit.

FALLING EQUIPMENT can injure.

- Use correct procedures and equipment of adequate capacity to lift and support unit.
- Follow the guidelines in the Applications Manual for the Revised NIOSH Lifting Equation (Publication No. 94−110) when manually lifting heavy parts or equipment.

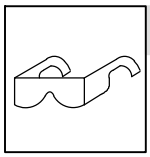
- Secure unit during transport so it cannot tip or fall.



READ INSTRUCTIONS.

- Read and follow all labels and the Owner's Manual carefully before installing, operating, or servicing unit. Read the safety information at the beginning of the manual and in each section.

- Use only genuine replacement parts from the manufacturer.
- Perform installation, maintenance, and service according to the Owner's Manuals, industry standards, and national, state, and local codes.



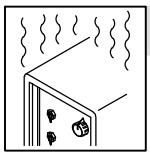
FLYING METAL or DIRT can injure eyes.

- Wear approved safety glasses with side shields or wear face shield.

ELECTRIC AND MAGNETIC FIELDS (EMF) can affect Implanted Medical Devices.

- Wearers of Pacemakers and other Implanted Medical Devices should keep away.

- Implanted Medical Device wearers should consult their doctor and the device manufacturer before going near arc welding, spot welding, gouging, plasma arc cutting, or induction heating operations.



OVERUSE can cause OVERHEATING.

- Allow cooling period; follow rated duty cycle.
- Reduce duty cycle before starting to weld again.

BATTERY EXPLOSION can injure.

- Do not use welder to charge batteries or jump start vehicles unless it has a battery charging feature designed for this purpose.

1-4. California Proposition 65 Warnings

WARNING: This product can expose you to chemicals including lead, which are known to the state of California to cause cancer and birth defects or other reproductive harm.

For more information, go to www.P65Warnings.ca.gov.

1-5. Principal Safety Standards

Safety in Welding, Cutting, and Allied Processes, ANSI Standard Z49.1, is available as a free download from the American Welding Society at http://www.aws.org or purchased from Global Engineering Documents (phone: 1-877-413-5184, website: www.global.ihs.com).

OSHA, Occupational Safety and Health Standards for General Industry, Title 29, Code of Federal Regulations (CFR), Part 1910.177 Subpart N, Part 1910 Subpart Q, and Part 1926, Subpart J, from U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954 (phone: 1-866-512-1800) (there are 10 OSHA Regional Offices—phone for Region 5, Chicago, is 312-353-2220, website: www.osha.gov).

National Electrical Code, NFPA Standard 70, from National Fire Protection Association, Quincy, MA 02169 (phone: 1-800-344-3555, website: www.nfpa.org and www. sparky.org).

Safety in Welding, Cutting, and Allied Processes, CSA Standard W117.2, from Canadian Standards Association, Standards Sales, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5NS (phone: 800-463-6727, website: www.csagroup.org).

Safe Practices for Welding and Cutting Containers that have Held Combustibles, American Welding Society Standard AWS A6.0, from Global Engineering Documents (phone: 1-877-413-5184, website: www.global.ihs.com).

Safe Practice For Occupational And Educational Eye And Face Protection, ANSI Standard Z87.1, from American National Standards Institute, 25 West 43rd Street, New York, NY 10036 (phone: 212-642-4900, website: www.ansi.org).

Standard for Fire Prevention During Welding, Cutting, and Other Hot Work, NFPA Standard 51B, from National Fire Protection Association, Quincy, MA 02169 (phone: 1-800-344-3555, website: www.nfpa.org).

1-6. EMF Information

Electric current flowing through any conductor causes localized electric and magnetic fields (EMF). The current from arc welding (and allied processes including spot welding, gouging, plasma arc cutting, and induction heating operations) creates an EMF field around the welding circuit. EMF fields can interfere with some medical implants, e.g. pacemakers. Protective measures for persons wearing medical implants have to be taken. For example, restrict access for passers–by or conduct individual risk assessment for welders. All welders should use the following procedures in order to minimize exposure to EMF fields from the welding circuit:

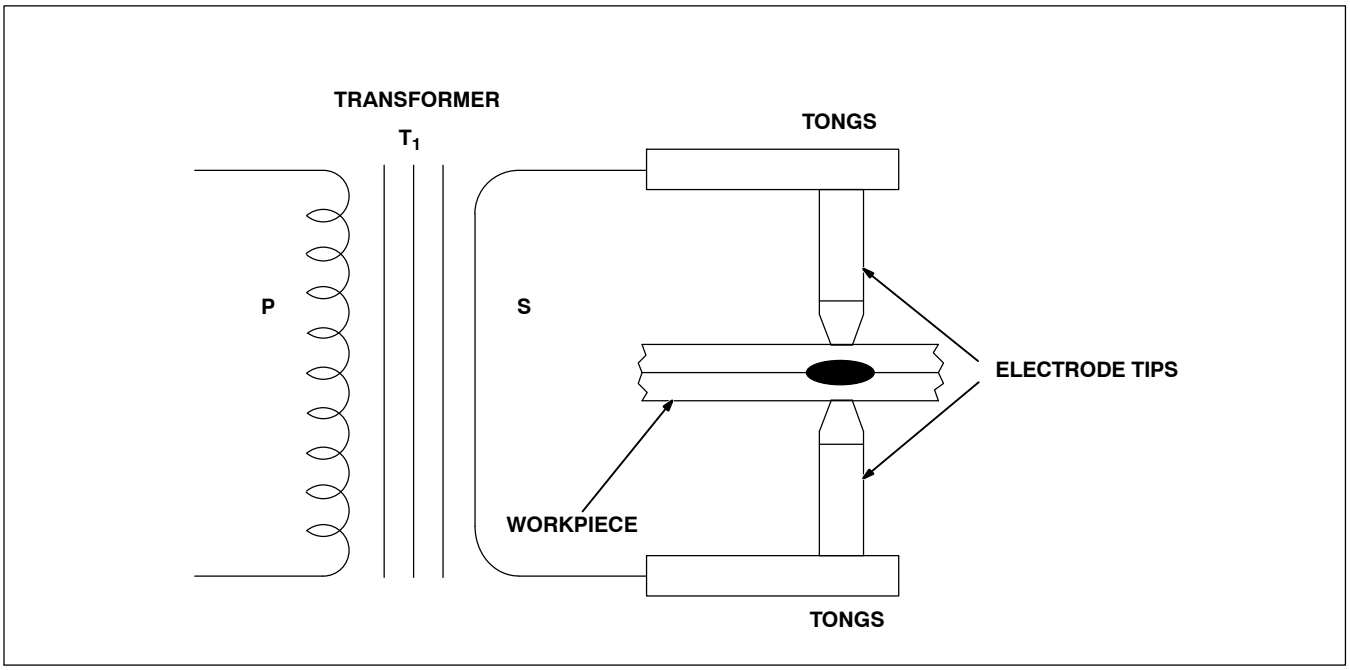
1. Keep cables close together by twisting or taping them, or using a cable cover.
2. Do not place your body between welding cables. Arrange cables to one side and away from the operator.
3. Do not coil or drape cables around your body.
4. Keep head and trunk as far away from the equipment in the welding circuit as possible.
5. Connect work clamp to workpiece as close to the weld as possible.
6. Do not work next to, sit or lean on the welding power source.
7. Do not weld whilst carrying the welding power source or wire feeder.

About Implanted Medical Devices:

Implanted Medical Device wearers should consult their doctor and the device manufacturer before performing or going near arc welding, spot welding, gouging, plasma arc cutting, or induction heating operations. If cleared by your doctor, then following the above procedures is recommended.

SECTION 2 – INTRODUCTION

Resistance welding is one of the oldest of the electric welding processes in use by industry today. The weld is made by a combination of heat, pressure, and time. As the name resistance welding implies, it is the resistance of the material to be welded to current flow that causes a localized heating in the part. The pressure exerted by the tongs and electrode tips, through which the current flows, holds the parts to be welded in intimate contact before, during, and after the welding current time cycle. The required amount of time current flows in the joint is determined by material thickness and type, the amount of current flowing, and the cross-sectional area of the welding tip contact surfaces. In the illustration below a complete secondary resistance spot welding circuit is illustrated. For clarity, the various parts of the resistance spot welding machine are identified.



Resistance Spot Welding Machine With Workpiece

SECTION 3 – FUNDAMENTALS OF RESISTANCE SPOT WELDING

3-1. Principle

Resistance welding is accomplished when current is caused to flow through electrode tips and the separate pieces of metal to be joined. The resistance of the base metal to electrical current flow causes localized heating in the joint, and the weld is made.

The resistance spot weld is unique because the actual weld nugget is formed internally in relation to the surface of the base metal. Figure 3-1 shows a resistance spot weld nugget compared to a gas tungsten-arc (TIG) spot weld.

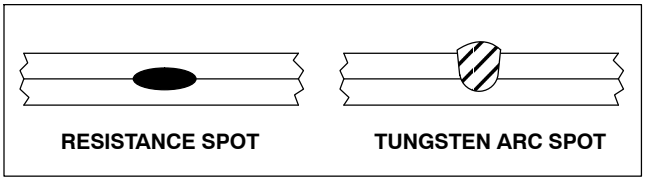


Figure 3-1. Resistance And TIG Spot Weld Comparison

The gas tungsten-arc spot is made from one side only. The resistance spot weld is normally made with electrodes on each side of the workpiece. Resistance spot welds may be made with the workpiece in any position.

The resistance spot weld nugget is formed when the interface of the weld joint is heated due to the resistance of the joint surfaces to electrical current flow. In all cases, of course, the current must flow or the weld cannot be made. The pressure of the electrode tips on the workpiece holds the part in close and intimate contact during the making of the weld. Remember, however, that resistance spot welding machines are NOT designed as force clamps to pull the workpieces together for welding.

3-2. Heat Generation

A modification of Ohm's Law may be made when watts and heat are considered synonymous. When current is passed through a conductor the electrical resistance of the conductor to current flow will cause heat to be generated. The basic formula for heat generation may be stated:

$$H = I^2R$$

H = Heat

I^2 = Welding Current Squared

R = Resistance

The secondary portion of a resistance spot welding circuit, including the parts to be welded, is actually a series of resistances. The total additive value of this electrical resistance affects the current output of the resistance spot welding machine and the heat generation of the circuit.

The key fact is, although current value is the same in all parts of the electrical circuit, the resistance values may vary considerably at different points in the circuit. The heat generated is directly proportional to the resistance at any point in the circuit.

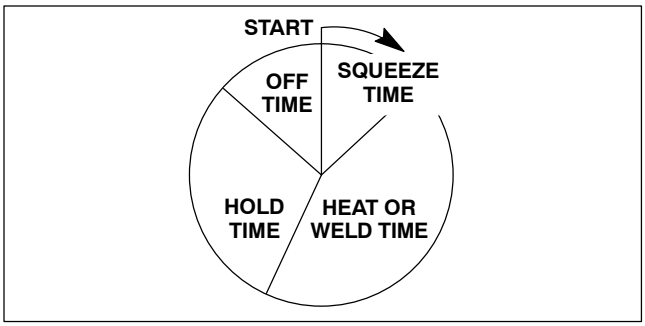


Figure 3-2. Spot Welding Time Cycle

Squeeze Time
Time between pressure application and weld.

Heat Or Weld Time
Weld time in cycles.

Hold Time
Time that pressure is maintained after weld is made.

Off Time
Electrodes separated to permit moving of material for next spot.

Resistance spot welding machines are constructed so minimum resistance will be apparent in the transformer, flexible cables, tongs, and electrode tips. The resistance spot welding machines are designed to bring the welding current to the weldment in the most efficient manner. It is at the weldment that the greatest relative resistance is required. The term “relative” means with relation to the rest of the actual welding circuit.

There are six major points of resistance in the work area. They are as follows:

1. The contact point between the electrode and top workpiece.
2. The top workpiece.
3. The interface of the top and bottom workpieces.
4. The bottom workpiece.
5. The contact point between the bottom workpiece and the electrode.
6. Resistance of electrode tips.

The resistances are in series, and each point of resistance will retard current flow. The amount of resistance at point 3, the interface of the workpieces, depends on the heat–transfer capabilities of the material, the material’s electrical resistance, and the combined thickness of the materials at the weld joint. It is at this part of the circuit that the nugget of the weld is formed.

3-3. The Time Factor

Resistance spot welding depends on the resistance of the base metal and the amount of current flowing to produce the heat necessary to make the spot weld. Another important factor is time. In most cases several thousand amperes are used in making the spot weld. Such amperage values, flowing through a relatively high resistance, will create a lot of heat in a short time. To make good resistance spot welds, it is necessary to have close control of the time the current is flowing. Actually, time is the only controllable variable in most single impulse resistance spot welding applications. Current is very often economically impractical to control. It is also unpredictable in many cases.

Most resistance spot welds are made in very short time periods. Since alternating current is normally used for the welding process, procedures may be based on a 60 cycle time (sixty cycles = 1 second). Figure 3-2 shows the resistance spot welding time cycle.

Previously, the formula for heat generation was used. With the addition of the time element, the formula is completed as follows:

$H = I^2RTK$

H = Heat

I^2 = Current Squared

R = Resistance

T = Time

K = Heat Losses

Control of time is important. If the time element is too long, the base metal in the joint may exceed the melting (and possibly the boiling) point of the material. This could cause faulty welds due to gas porosity. There is also the possibility of expulsion of molten metal from the weld joint, which could decrease the cross section of the joint and weaken the weld. Shorter weld times also decrease the possibility of excessive heat transfer in the base metal. Distortion of the welded parts is minimized, and the heat affected zone around the weld nugget is substantially smaller.

3-4. Pressure

The effect of pressure on the resistance spot weld should be carefully considered. The primary purpose of pressure is to hold the parts to be welded in intimate contact at the joint interface. This action assures consistent electrical resistance and conductivity at the point of weld. The tongs and electrode tips should NOT be used to pull the workpieces together. The resistance spot welding machine is not designed as an electrical “C” clamp! The parts to be welded should be in intimate contact BEFORE pressure is applied.

Investigations have shown that high pressures exerted on the weld joint decrease the resistance at the point of contact between the electrode tip and the workpiece surface. The greater the pressure the lower the resistance factor.

Proper pressures, with intimate contact of the electrode tip and the base metal, tend to conduct heat away from the weld. Higher currents are necessary with greater pressures and, conversely, lower pressures require less amperage from the resistance spot welding machine. This fact should be carefully noted, particularly when using a heat control with the various resistance spot welding machines.

3-5. Electrode Tips

Copper is the base metal normally used for resistance spot welding tongs and tips. The purpose of the electrode tips is to conduct the welding current to the workpiece, to be the focal point of the pressure applied to the weld joint, and to conduct heat from the work surface. The tips must to maintain their integrity of shape and characteristics of thermal and electrical conductivity under working conditions.

Electrode tips are made of copper alloys and other materials. The Resistance Welders Manufacturing Association (RWMA) has classified electrode tips into two groups:

Group A – Copper based alloys

Group B – Refractory metal tips

The groups are further classified by number. Group A, Class I, II, III, IV, and V are made of copper alloys. Group B, Class 10, 11, 12, 13, and 14 are the refractory alloys.

Group A, Class I electrode tips are the closest in composition to pure copper. As the Class Number goes higher, the hardness and annealing temperature values increase, while the thermal and electrical conductivity decreases.

Group B compositions are sintered mixtures of copper and tungsten, etc., designed for wear resistance and compressive strength at high temperatures. Group B, Class 10 alloys have about 40 percent the conductivity of copper with conductivity decreasing as the number value increases. Group B electrode tips are not normally used for applications in which resistance spot welding machines would be employed.

3-6. Practical Uses Of Resistance Spot Welding

Spot Welding can be hazardous. Read and follow the Safety information at front of this book. Also read and follow the equipment labels and owner's manual carefully.

As current density is increased, the weld time is decreased proportionately. If, however, the current density becomes too high, there is the possibility of expelling molten metal from the interface of the joint thereby weakening the weld. The ideal time and current density condition is somewhere just below the level of causing metal to be expelled.

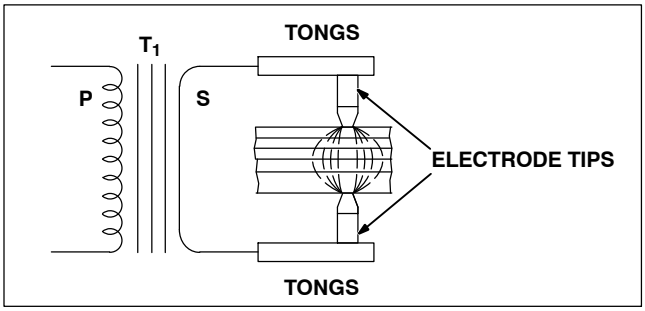


Figure 3-3. Resistance Spot Weld Heat Zones

It is apparent that the heat input cannot be greater than the total dissipation rate of the workpiece and the electrode without having metal expelled from the joint.

Thoughts have changed concerning the flow of current through the workpiece. Previously, current was considered to flow in a straight line through the weld joint. This is not necessarily true when multiple thicknesses of material are being welded.

The characteristic is for the current to "fan out", thereby decreasing the current density at the point of weld the greatest distance from the electrode tips. The illustration (Figure 3-3) shows the resistance spot weld heat zones for several thicknesses of metal. Note that the uncontrollable variables (such as interface contamination) are multiplied when resistance spot welding several thicknesses of material. Quality levels will be much lower for "stack" resistance spot welding, which explains why such welding practices are avoided whenever possible.

Disregarding the quality factor, it becomes apparent that the number of thicknesses of a material which may be successfully resistance spot welded at one time will depend on the material type and thickness as well as the KVA capacity of the resistance spot welding machine.

KVA rating, duty cycle, and other pertinent information is shown on all resistance spot welding machine nameplates. The catalog literature and the operating manuals provide data on the maximum combined thicknesses of material that each unit can weld. A table showing the various models of resistance spot welding machines is located in the back of this book.

3-7. Electrode Tip Size

When you consider that it is through the electrode that the welding current is permitted to flow into the workpiece, it is logical that the size of the electrode tip point controls the size of the resistance spot weld. Actually, the weld nugget diameter should be slightly less than the diameter of the electrode tip point. If the electrode tip diameter is too small for the application, the weld nugget will be small and weak. If, however, the electrode tip diameter is too large, there is danger of overheating the base metal and developing voids and gas pockets. In either instance, the appearance and quality of the finished weld would not be acceptable.

Determining electrode tip diameter requires some decisions on the part of the weldment designer. The resistance factors involved for different materials will certainly have some bearing on electrode tip diameter determination. A general formula has been developed for low carbon steel. It will provide electrode tip diameter values that are usable for most applications.

☞ *The tip diameter discussed in this text refers to the electrode tip diameter at the point of contact with the workpiece. It does not refer to the major diameter of the total electrode tip.*

The formula generally used for low carbon steel is as follows:

Electrode tip diameter = 0.100 in. + 2t

where " t " is the thickness in inches of one thickness of the metal to be welded. This formula is applicable to the welding of metals of dissimilar thicknesses. The formula is applied to each thickness individually, and the proper electrode tip diameter selected for each size of the joint.

For example, if two pieces of 0.062 in. sheet metal are to be joined, the electrode tip diameter would be the same for both sides of the joint. The calculation would be as follows:

Electrode tip dia. = 0.100 + 2t

= 0.100 + 2 x 0.062 in.

= 0.100 + 0.124 in.

Electrode tip dia. = 0.224 in.

If the two pieces were unequal in thickness, such as one piece 0.062 in. and the other 0.094 in., two calculations would have to be made. Each thickness would be treated as the basis for one electrode tip diameter determination, as follows:

Electrode tip dia. = 0.100 + 2t

= 0.100 + 2 x 0.062 in.

= 0.100 + 0.124 in.

Electrode tip dia. = 0.224 in. (one side only)

For the other side, the calculation is as follows:

Electrode tip dia. = 0.100 + 2t

= 0.100 + 2 x 0.094 in.

= 0.100 + 0.188 in.

Electrode tip dia. = 0.288 in. (one side only)

Remember that the formula is applicable to low carbon steels and may not be correct for other materials.

3-8. Pressure Or Welding Force

The pressure exerted by the tongs and the electrode tips on the workpiece has a great effect on the amount of weld current that flows through the joint. The greater the pressure, the higher the welding current value will be, within the capacity of the resistance spot welding machine.

Setting pressure is relatively easy. Normally, samples of material to be welded are placed between the electrode tips and checked for adequate pressure to make the weld. If more or less pressure is required, the operating manual for the resistance spot welding machine will give explicit directions for making the correct setting. As part of the equipment set-up, the tong and electrode tip travel should be adjusted to the minimum required amount to prevent "hammering" the electrode tips and tip holders.

3-9. Heat Balance

There is no particular problem of heat balance when the materials to be welded are of equal type and thickness. The heat balance, in such cases, is automatically correct if the electrode tips are of equal diameter, type, etc. Heat balance may be defined as the conditions of welding in which the fusion zone of the pieces to be joined are subjected to equal heat and pressure.

When the weldment has parts of unequal thermal characteristics, such as copper and steel, a poor weld may result for several reasons. The metals may not alloy properly at the interface of the joint. There may be a greater amount of localized heating in the steel than in the copper. The reason would be because copper has low electrical resistance and high thermal transfer characteristics, while steel has high electrical resistance and low thermal transfer characteristics.

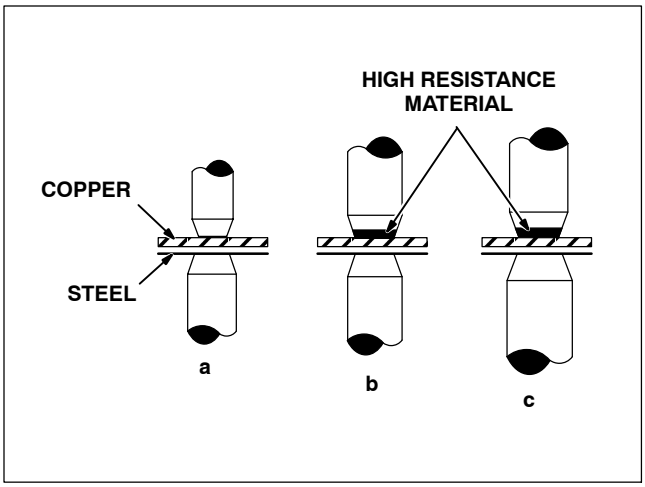


Figure 3-4. Techniques For Obtaining Heat Balance

Correct heat balance may be obtained in a weldment of this type by one of several methods. Figure 3-4 illustrates three possible solutions to the problem. Figure 3-4 (a) shows the use of a smaller electrode tip area for the copper side of the joint to equalize the fusion characteristics by varying the current density in the dissimilar materials.

Figure 3-4 (b) shows the use of an electrode tip with high electrical resistance material, such as tungsten or molybdenum, at the contact point. The result is to create approximately the same fusion zone in the copper as in the steel. A combination of the two methods is shown in Figure 3-4 (c).

3-10. Surface Conditions

All metals develop oxides which can be detrimental to resistance spot welding. Some oxides, particularly those of a refractory nature, are more troublesome than others. In addition, the mill scale found on hot-rolled steels will act as an insulator and prevent good-quality resistance spot welding. Surfaces to be joined by this process should be clean, free of oxides and chemical compounds, and have a smooth surface.

3-11. Materials Data For Resistance Spot Welding

This section of the text will consider methods used for resistance spot welding some of the common metals that are used in fabrication work. It is not intended that all the possible problems that could arise will be answered. The purpose of this part of the text is to provide general operational data for use with resistance spot welding machines. Where applicable, the data provided will be related to specific models and size (kVA) of units. **The units listed in this section are not recommended for aluminum or copper alloys.**

3-12. Mild Steel

Mild or low-carbon steel comprises the largest percentage of material welded with the resistance spot welding process. All low-carbon steels are readily weldable with the process if proper equipment and procedures are used.

The carbon steels have a tendency to develop hard, brittle welds as the carbon content increases if proper post-heating procedures are not used. Quick quenching of the weld, where the nuggets cools rapidly, increases the probability of hard, brittle micro-structure in the weld. Hot rolled steel will normally have mill scale on the surface of the metal. This type of material is usually not resistance spot welded with resistance welding machines of the kVA ratings of Miller-built units.

Cold rolled steel (CRS) and hot rolled steel, pickled and oiled (HRSP & O), may be resistance spot welded with very little trouble. If the oil concentration is excessive on the sheet metal, it could cause the formation of carbon at the electrode tips thereby decreasing their useful life. De–greasing or wiping is recommended for heavily oiled sheet stock.

The resistance spot weld should have shear strength equal to the base metal shear strength and should exceed the strength of a rivet or a fusion plug weld of the same cross sectional area. Shear strength is normally accepted as the criteria for resistance spot weld specifications, although other methods may be used.

A common practice is to “peel” two welded sample strips apart to see if a clean “rivet” is pulled from one piece. If it is, the resistance spot welding condition is considered correct.

With magnetic materials such as mild steel, the current through the weld can vary substantially depending on how much of the magnetic material is within the tong loop. The tong loop is sometimes called the “throat” of the resistance spot welding machine.

For example, the part to be welded may have the largest amount of the base metal within the throat of the unit for any one resistance spot weld and almost none of the base metal in the throat for the second spot weld. The current at the weld joint will be less for the first weld. The reason is the reactance caused by the ferrous material within the arc welding circuit.

Resistance spot welding machines are applicable to low carbon steel welding. For best results, they must be used within their rated capacity of total thickness of material. They should not be operated beyond the specified duty cycle or the contactor and transformer may be damaged. The 50 percent duty cycle for this type of equipment should be adequate for all applications within their rating. The RWMA standard rating for general duty resistance welding machines is 50 percent duty cycle. Duty cycle is based on a 10 second time frame and a 50 percent duty cycle means the unit can weld 5 seconds out of each 10 second time period without overheating.

Table 3-1 provides the rating information for all models of resistance spot welding machines. The open-circuit voltage and short-circuit current for different tong lengths, etc., are given. The short-circuit current values are according to RWMA test procedures for copper-to-copper contact. The values considered do not have weld metal between the tips. The combined metal thickness that each model can accommodate is also shown.

3-13. Low Alloy And Medium Carbon Steels

There are some pertinent differences in resistance spot welding low alloy and medium carbon steels as compared to mild or low carbon steels. The resistance factor for the low alloy and medium carbon steels is higher; therefore, the current requirements are slightly lower. Time and temperature are more critical since metallurgical changes will be greater with these alloys. There is certainly more possibility of weld embrittlement than there is with mild steel.

Resistance spot welding pressures are normally higher with these materials because of the additional compressive strength inherent in the low alloy and medium carbon steels. It is always a good idea to use longer welding times when welding these alloys to retard the cooling rate and permit more ductile welds.

3-14. Stainless Steels

The chrome-nickel steel alloys (austenitic) have very high electrical resistance and are readily joined by resistance spot welding. The consideration of great importance with these materials is rapid cooling through the critical range, 800°F to 1400°F. The rapid quench associated with resistance spot welding is ideal for reducing the possibility of chromium carbide precipitation at the grain boundaries. Of course, the longer the weldment is held at the critical temperatures, the greater the possibility of carbide precipitation.

3-15. Steels, Dip Coated Or Plated

The overwhelming majority of material in this category is galvanized, or zinc-coated steel. Although some galvanized steel is electroplated, the dip-coated steel costs less and is predominantly used. The zinc coating is uneven in thickness on dip-coated steel. The resistance factor will vary from weld to weld, and it is very difficult to set conditions in chart form for the material.

It is impossible to maintain the integrity of the galvanized coating when resistance spot welding. The low melting point of the zinc coating, compared to the fusion temperature of the steel sheet, causes the zinc to vaporize. Of course, there must be adequate pressure to force the zinc aside at the weld interface to permit steel-to-steel fusion. Otherwise, the strength of the resistance spot weld is open to question.

Materials are available to repair the external damage to the coating that may be incurred because of the welding heat. There is no remedy for the loss of coating material at the interfaces of the weld, unfortunately. In fact, the vaporization of the zinc can cause porosity in the weld and a general weakening of the expected shear strength.

Do not weld on coated metals, such as galvanized, lead, or cadmium plated steel, unless the coating is removed from the weld area, the area is well ventilated, and while wearing an air-supplied respirator. The coatings and any metals containing these elements can give off toxic fumes if welded.

Wear protective garments such as oil-free, flame-resistant leather gloves, heavy shirt, cuffless trousers, high shoes, and a cap. Synthetic material usually does not provide such protection.

Other coated material, such as terne plate (lead coated) may have varying degrees of toxicity. Adequate ventilation is mandatory when working with these materials.

The vaporization of the coating material has a tendency to foul the electrode tips. The tips should be cleaned frequently to prevent the alloying of the lower melting materials with the copper tips. The tips may require cleaning and dressing every fourth or fifth weld to maintain quality in the product, although for some galvanized applications the best welds are made after several spots blacken the tips. The use of short weld times will increase the possibility of good welds with the least amount of tip fouling.

3-16. Aluminum And Aluminum Alloys

Resistance spot welding machines with kVA ratings much greater than 20 kVA are necessary to make sound welds on most aluminum materials and any other high–conductivity type of base metal. The electrical conductivity of aluminum is high, and welding machines must provide high currents and exact pressures in order to provide the heat necessary to melt the aluminum and produce a sound weld.

3-17. Summary

Resistance spot welding is a welding technique that is used for almost all known metals. The actual weld is made at the interface of the parts to be joined. The electrical resistance of the material to be welded causes a localized heating at the interfaces of the metals to be joined. Welding procedures for each type of material must be developed for the most satisfactory results.

It is possible that shunt currents flowing through a previously made spot weld will take welding current away from the second second spot weld to be made. This will occur if the two spot welds are too close together, and it will happen with all metals.

The following table is intended as a guide for setting up resistance spot welding procedures. The exact time, pressure, and current setting will depend on the specific application and the kVA rating of the resistance spot welding machine employed.

Table 3-1. Resistance Spot Welding Machine Specifications

Model	KVA Rating	Rated Output 6 in. Tongs	Rated Output 12 in. Tongs	Rated Output 18 in. Tongs	Open Circuit Voltage	Max. Capacity** Uncoated Mild Steel, Combined Thickness Using 6 in. Tongs
MSW-41	1.5	5,550	4,500	3,600	1.6	1/8 in.
MSW-41t*	1.5	5,550	4,500	3,600	1.6	1/8 in.
LMSW-52	2.5	6,750	5,800	4,850	2.5	3/16 in.
LMSW-52t*	2.5	6,750	5,800	4,850	2.5	3/16 in.
SSW-2020	20	12,500	10,500	9,000	3.55	1/4 in.
SSW-2040	20	12,500	10,500	9,000	3.55	1/4 in.

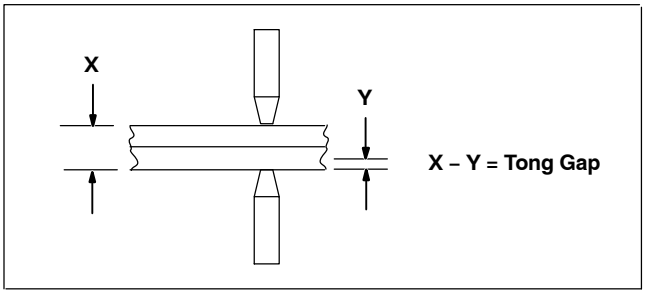
* "t" series feature an automatic timer.

** Ratings are for uncoated mild and low carbon steel with 6 in. tongs. For other metals, the combined thickness will have to be determined.

The following general data is provided to assist the operator in setting up welding procedures when using any of the resistance spot welding machines listed in Table 3-1.

Turn off unit and disconnect input power.

1. Close tongs and measure space between electrode tip contact surfaces.
2. Measure the thickness of the total weldment.
3. Adjust tong gap to measurement of Step 2 less 1/2 the thickness of the thinnest workpiece to be welded.



4. Insert the parts to be welded between the electrode tips and bring tips to welding pressure. There should be a slight deflection of the tongs. This may be measured with a straight edge set on the tong longitudinal axis.
5. Energize the spot welding machine and make a sample weld.
6. Test the weld by visual and mechanical means. Check the electrode tip for deformation and contamination (see Test Procedures).
7. Adjust tong pressure as required (see equipment manual for tong adjustment procedures).

3-18. Test Procedures

The test procedures outlined are very simple and require a minimum of equipment to perform.

1. Visual Test

   Observe the deformation and shape of the surface contact points at both sides of the weld.
   Excessive "dishing" of the surface contact point indicates one or more of the following:

   a. Excessive tong pressure.

   b. Weld time too long.

   c. Misalignment of the electrode tips.

   If the resistance spot weld does not have an even, concentric surface appearance, the problem could be misalignment of the electrode tips. Align electrode tips with the power off and a typical weld joint between the tip surfaces.

2. Mechanical Test

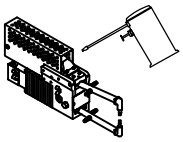
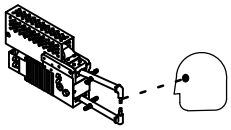
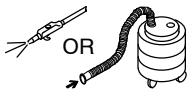
   Place one end of the resistance spot weld sample in vice jaws. Use mechanical means to force the weld apart. One side of the weld should pull loose from the parent metal with a metal extension from the weld. Check for proper weld diameter.

SECTION 4 – MAINTENANCE AND TROUBLESHOOTING

4-1. Maintenance

Disconnect power before maintaining.

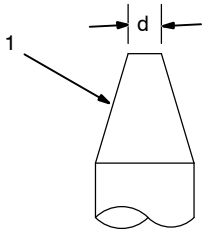
☞ *During heavy service, maintain monthly.*

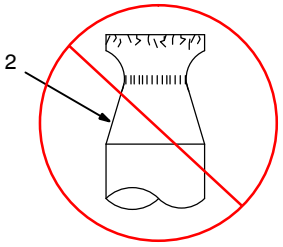
	✓ = Check ◇ = Change ● = Clean ☆ = Replace * To be done by Factory Authorized Service Agent			Reference
Every 3 Months	 ● - Oil unit	 ✓ - Inspect Tips	 ✓ ☆ – Replace Damaged or Unreadable Labels	See Owner's Manual
Every 6 Months	 During Heavy Service, Clean Monthly ✓ ● – Blow Off Or Vacuum Unit			See Owner's Manual

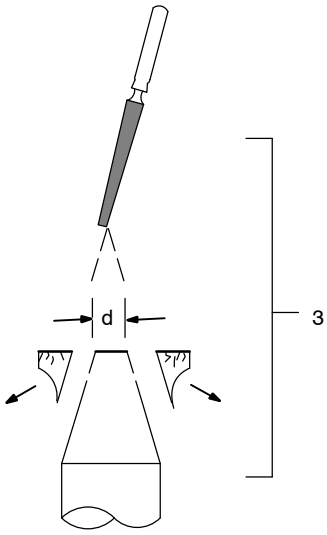
4-2. Dressing Tips

1 New Tip
2 Used Tip Requiring Dressing
3 Dressing Method – Keep top diameter same as a new tip.

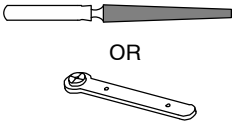
☞ *Diameter "d" equals 3/16 – 1/4 in. (4.8 – 6.4 mm).*







Tools Needed:



4-3. Troubleshooting

Trouble	Remedy
Tips overheating.	Not enough tong pressure. Increase tong pressure.
	Weld time too long. Reduce weld time.
	Material too thick for the spot welding machine.
Tips arcing on material.	Not enough tong pressure. Increase tong pressure.
	Tips not aligned correctly. Realign tips or dress tips to proper diameter (see Section 4-2).
	Base material may be welded to tips causing high resistance and poor electrical current flow. Clean or dress tips (see Section 4-2).
Spatter or molten material being expelled out during welding operation.	Incorrect tip alignment. Dress tips so that they align and are flat on the material (see Section 4-2).
	Excessive tong pressure. Reduce tong pressure.
	Output amperage too high. Reduce amperage setting, if applicable (not available on air-cooled models).
	Weld time too long. Reduce weld time.
Inconsistent weld nugget.	Inconsistent weld time. Install a weld timer, if applicable.
	Not enough tong pressure. Increase tong pressure.
Hole in middle of weld.	Contact area of tips is too large. Change to a smaller tip diameter or dress tips back to original diameter (see Section 4-2).
Poor weld or no weld at tips.	Material too thick for spot welding machine. Check that material thickness is within capacity of spot welding machine.
	Tongs are too long. Reduce tong length.
	Remove coating from material for intimate contact between pieces. Remove oxides and chemical compounds including galvanized coating.

Notes

Notes

Notes

Notes

Owner's Record

Please complete and retain with your personal records.

Model Name	Serial/Style Number
Purchase Date	(Date which equipment was delivered to original customer.)
Distributor	
Address	
City	
State	Zip

For Service

Contact a DISTRIBUTOR or SERVICE AGENCY near you.

Always provide Model Name and Serial/Style Number.

Contact your Distributor for:	Welding Supplies and Consumables Options and Accessories Personal Safety Equipment Service and Repair Replacement Parts Training (Schools, Videos, Books) Technical Manuals (Servicing Information and Parts) Circuit Diagrams Welding Process Handbooks To locate a Distributor or Service Agency visit www.millerwelds.com or call 1-800-4-A-Miller
Contact the Delivering Carrier to:	File a claim for loss or damage during shipment. For assistance in filing or settling claims, contact your distributor and/or equipment manufacturer's Transportation Department.

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